

VOL. IV, PP. 85-109

MARCH 18, 1902

THE  
NATIONAL GEOGRAPHIC MAGAZINE

GEOGRAPHY OF THE AIR

ANNUAL REPORT BY VICE-PRESIDENT

HERBERT A. W. COHEN



WASHINGTON

PUBLISHED BY THE NATIONAL GEOGRAPHIC SOCIETY

NO. 1212

PRICE 10 CENTS



THE  
NATIONAL GEOGRAPHIC MAGAZINE

---

GEOGRAPHY OF THE AIR.

ANNUAL REPORT BY VICE-PRESIDENT,

GENERAL A. W. GREELY.

*(Presented by title before the Society January 22, 1902.)*

---

If the poet finds retrospection one of the delights of the mind, the investigator finds it to be a useful mental process at certain stages in order the better to determine not only the results certainly attained but also the methods and directions promising most in the future. Such a retrospective study has not infrequently been more valuable to the scientist than would an uninterrupted continuance of his investigations involving double the effort.

The object of these annual reports is to give yearly, for the benefit of the Society, a retrospective glance to appropriate branches of physical sciences or physical research.

I have said physical "research" as well as science, for only the enthusiastic yet class my subject—meteorology—as a science, certainly no one as an exact science. It is of course a matter of opinion as to when the epoch arrives wherein any distinct department of nature can be properly designated as a science, and as being no longer an immense aggregation of facts, theories and assumptions. Within the century the world has seen chemistry, mineralogy, botany, zoology and other now recognized sciences emerge from their previously uncertain and indefinite

status. Of meteorology, however, using this term as especially applying to weather and not to climate, which will be referred to later, it may fairly be said that the generalizations are too indefinite in terms and too scanty in number, the ascertained and acknowledged facts too insufficient as well as too disjointed in their relations, to form the indispensable work of fundamental principles upon which is to be woven the regular, graceful curves which nature ever presents to us under the magic word as woven by the specialist in any science.

The term "science" carries with it in a degree the idea of precision, so that exemplifications of its principles shall always find expression in foreseen results, whose ultimate variations should not exceed certain narrow limits.

Abercrombie and the writer have published, almost simultaneously, the latest works in English on the weather. My own opinions as to the status of this department of nature were clearly put in "American Weather," 1888. To quote:

"All skilled meteorologists realize how comparatively local are weather conditions and how impossible it is, at times, to make predictions for a definite period with any feeling of certainty. \* \* \* It is evident that fair-weather conditions are those which are most persistent [i. e., they partake more of climatic conditions than of weather] and from the prediction of which the highest percentages of accuracy will be obtained."

Professor Marvin, a careful, conscientious official, whose duty has included the examination and verification of forecasts, after three years of study, says (referring to verification-percentages not being strictly comparable) in confirmation: "The reasons for this are principally because of the much greater difficulty of successfully forecasting rainy and unsettled than fair weather, together with the seasonal sporadic variations in their respective occurrences." His illustrations make clear what has been believed by all close observers, namely, that high percentages and satisfactory forecasts are attendant on the persistency of climatic or permanent conditions (such as no summer rain in California) when unbroken by the violent and marked changes which distinguish weather from climate.

It is safe to say that the percentage of successful forecasts of rain twenty-four hours in advance is not one-half, and probably not more than one-third, so successful as forecasts of fine, clear weather for the same period.

The scientific investigator or student who longest applied himself to the study of American weather endeavored a few years since to deduce a practical rule for weather forecasts which might be applied to current and daily work. It is significant that no single application of this rule or theory has ever been made. If the test had been made it is to be feared that the criticism of Strachey would recur, viz, that theory finds not its counterpart in actual values.

It may or may not be indicative of the state of meteorology that the eleven rules for practical predictions laid down by me in "American Weather" in 1888 have received no accretions. Many are willing to indulge in criticism and glittering generalities, but in any scientific work practical and particular applications are demanded. Careful and continued observations have indeed determined the usual paths of storms, but most uncertain and so far indeterminate have been all researches to so determine the cause of storm development and movement that from observed meteorological phenomena can be seen not only the certainty of the storm's approach but also its particular course.

What do experts abroad think? Abercrombie says: "The service of weather forecasting can never be treated mathematically \* \* \* Many isolated principles have been discovered, but no attempt has been made to lay down the broad principles of the science of the weather as a whole." The terse dictum that "The successive changes in the *shape* of isobars \* \* \* indicate the sequence of weather in any place" is declared to be the fundamental principle of all synoptic meteorology, and we have only to work out the local details connected with the changes of isobars to formulate and connect therewith sequent and appertaining weather changes.

It may well be questioned if any meteorological expert outside of the British office accepts this principle or limitation of Abercrombie's. Statistical methods, he goes on to remark, are practically devoid of physical significance, and through misuse have tended to bring modern meteorology into disrepute. While most meteorologists agree with him in their disapproval of certain statistical methods as applicable to meteorology, yet they endorse others, these or those according to circumstances, as valuable or invaluable aids to successful work in weather forecasting.

Among investigators following statistical methods is M Teie-

science de Bort, the very able assistant of Professor Mascart in France, who believes that the recurring weather changes can be referred to types, and who has devoted his perspicacity, talents and industry to the solution of the problem for France in particular and Europe in general.

While perhaps no scientist of high standing now invokes the moon's phases as potent factors in weather changes, yet the influence of atmospheric electricity is believed by some to possibly dominate the weather, while again others turn to terrestrial or interplanetary magnetism as the essential basis.

Not a few distinguished physicists refer the whole question directly to the radiative energy of the sun, which all, however, necessarily admit as an ultimate and predominating cause. When, however, we come to particularly apply the principle, a distinguished English astronomer claimed that the rainfall of India (which may be said to be the weather of that country) follows in its phases the curve of sun-spots. Immediately the meteorological reporter, Mr. Blandford, proved that not only was this not true of the locality directly referred to, but that in India there was no year in which extended areas of country did not present striking contrasts as to precipitation, excesses in some provinces and marked deficiencies in others.

It is significant that in an article of 45 pages in the *Encyclopedia Britannica*, Buchan gives no law for any meteorological phenomenon, and says, referring to the formulas of Ferrel, Mohn, Hann, Everett and others, that in "The development of the law of the relation of the wind's velocity to the barometric gradients," the evident inexactness of the various investigations justify Strachan's criticism that "The theoretical values do not accord with the actual values."

Delannoy, in announcing a new theory of storms, says that meteorology has not yet emerged from the domain of observation, is now unprogressive, and, in fact, under present methods has reached its limits as a science. Further progress is only possible by ascertaining the causes of meteorological disturbances and in defining the fixed laws which bring about weather changes. Similar opinions could be drawn from other authorities if time and space permitted.

When the duties of forecasting storms devolved by Congressional joint resolution of February 9, 1870, on the War department, its success was by many considered most doubtful, espe-



cially in view of the fact that the efforts of Admiral Fitz Roy in Great Britain had resulted so unsatisfactorily. The problem was to evolve out of unknown and unsatisfactory conditions a system suited to America, or in other words, a system that should ensure to citizens and tax-payers practical results commensurate with expenditures. How the system of weather forecasting was built up in detail, it is neither the province nor purpose of this report to consider. It is, however, not a theory but a fact that under the military administration this service thrived wonderfully; though be it understood the military administration is no more endorsed in all its details than is the civilian administration of governmental bureaus in all its details. Bickerings, jealousies, repressions, maladministration and inefficiency are not necessary characteristics of either civilian or military methods, nor can either be absolutely free therefrom. In short, in every bureau the ability, application, energy and all the common-sense characteristics of its chief, be they great or little, find their exaggerated reflex in the work done and the policy followed, in the working out of details and in the accomplishment of results.

The Weather bureau of the United States, however, soon speedily attained a degree of efficiency and success sufficient to commend it not only to the practical American citizen, but yet more to the admiring judgment of foreign scientists, who, inspired by the satisfactory work in the United States, speedily increased the scope of their own duties or persuaded the government to initiate a like system for their own country.

The conference of European meteorologists at Leipzig in 1872 resulted in a national congress at Vienna in 1873; and in an official invitation extended to the government of the United States to take part, it is said—"The wonderful results which have been obtained by meteorological observations on this continent [the United States] renders its participation in the aforesaid congress highly desirable;" and the hope is expressed that this government will, "In the interests of science and the general welfare, unite through its representatives at this congress the experience of its meteorological institutes to the observations of the meteorologists of Europe."

The Universal exhibition at Prussia in 1876, in considering the Signal service exhibit, acknowledged in express terms that no award within the power of the committee would adequately

express its appreciation of the merits of the Signal service meteorological exhibit, and consequently sent a special letter. A diploma of honor, the highest award granted, was received from the National exhibition of electricity at Paris; and a letter of distinction, also the highest award, came from the Geographical exhibition congress at Vienna, Austria, for tri-daily weather charts.

Some Americans may deprecate the strong language used in these resolutions, but it should be borne in mind that distance is necessary to give a just perspective to all great undertakings. If it be considered that no nation can justly estimate the labor and effect either of its ordinary and average contributions to modern progress or of its greatest achievements, so a just opinion of the ability displayed in the management of any service, or of the results obtained, can rarely, if ever, be given by the scientists of that country. Their mental vision is liable to distortion, perhaps through indifference to or distaste for the work in question; perhaps by a sense of present or fear of possible encroachment on their own lines of research; perhaps by a feeling of scientific jealousy, either personal to the staff concerned or general as to the branch of natural science under inquiry. One does not have to go out of the city of Washington to hear disparaging and unprofessional reflections on the scientific standing of persons, the highest in the opinion of the world in their specialties; and as with men, so with bureaus.

Be this as it may, the Weather bureau under military administration has made its indelible impression upon the meteorological societies of all civilized countries from year to year; and even in countries where a lurking suspicion of jealousy toward the growing scientific importance of the United States has existed, in these countries as in all others the means and methods employed in the United States are being followed.

It was interesting at the late conference of meteorological chiefs in September, 1891, at Munich, Bavaria, to note from time to time that the military Weather bureau of the United States had been the only office which had endeavored to live up to the scientific meteorological ideals elaborated and endorsed by previous conferences and congresses. Similarly it may be mentioned that the same peculiarity developed at the International polar congress, wherein it appears that the United States,



through the Signal service, was the only country which had endeavored to follow the line of obligation agreed on for international use in publication.

If for no other reason, meteorology owes its debt of gratitude to an officer of the army, the late General Myer, from whose mind in August, 1873, proceeded the idea of an exchange of international telegraphic weather reports as widely as possible, and to whose initiative in connection with the congress at Vienna is due the unparalleled, important and successful international meteorological work.

During thirteen years, 1875 to 1887 inclusive, the land observations of this service covered the countries of almost the entire northern hemisphere and a part of the southern hemisphere, and reports were also received from regular naval and merchant marine vessels of the principal countries of the northern hemisphere. More than 150,000 monthly reports, representing upwards of 5,000,000 daily simultaneous observations, were received, collected, and published or charted by the Signal office. The number of vessel reports reached 600, and the foreign land stations increased to a total of 459, exclusive of the international polar stations. The following countries coöperated during a part or a whole of the period 1875 to 1887: Algeria, Australia, Austria-Hungary, Belgium, Brazil, Great Britain, Canada, Cape Colony, Chili, China, Costa Rica, Denmark, Egypt, France, Germany, Greece, Hawaiian Islands, India, Italy, Japan, Mauritius, Mexico, the Netherlands, Norway, Russia, Scotland, Spain, Sweden, Switzerland, Turkey. In addition to the reports furnished by the regular services of the several countries, observations were made and forwarded from the islands of the northern Atlantic ocean, of Central America and northern South America, and from Bering Island, the Aleutian islands, Alaska, Greenland and Iceland.

The international publications of the Signal service, which commenced with the regular issue of the daily bulletin of simultaneous observations in July, 1875, embodied data whose value cannot be overestimated. The network of stations which covered the northern hemisphere for a period of years furnished a vast number of reliable observations, the study of which has in no small measure contributed to recent discoveries and advances in meteorology, and in future investigations these observations will be invaluable.

These publications and charts are based upon an unparalleled series of observations; they represent graphically the labor of meteorologists throughout the civilized world for a period of thirteen years; they are unique in the annals of meteorology; and their proper presentation, rendered impracticable heretofore owing to insufficiency of funds, is alone needed to class them with the most treasured products of modern meteorology. In completing this work, the Signal office has compiled maps showing the mean pressure of the northern hemisphere as deduced from ten years observations under this system, and the changes in pressure from month to month; and it has also charted the average storm frequency for each month of the year.

In considering these great labors, one may be named who is no longer sensitive to criticism, the late General Albert J. Myer, whose diplomatic skill and wonderful persistency in dealing with the legislative branch of the government and whose judgment in selecting his subordinates ensured ultimately both a financial support for the service in general, and also an excellence of execution in general weather predictions and in detailed work throughout the country which have never been attained by any other meteorological service in the world. Their theoretically equal credit is due to the late Professor Ferrel, whose relations were maintained with the Signal service until he sought his well earned retirement, and from whose intelligent ability and aptitude for research have proceeded the most complete and satisfactory treatises on meteorology from a scientific and mathematical standpoint. The important services rendered by other distinguished professors merit similar praise.

As to the officers and professors forming the general staff of the bureau, it may be remarked that their labors in organizing, developing and spending the meteorological work of this service will never be adequately stated or generally recognized. It is, however, a matter of record that the meteorological system devised by officers of the United States army has proved to be the most successful practical service in the world, and has served as a working model and example for other nations, while its unique exhibits have elicited unparalleled commendation. The records of such officers as have participated in the work of this service for any prolonged period show the native ability and special adaptitude of army officers, when ordered to scientific duty for which they had not been educated and which more than one

accepted with reluctance, and a process of fusion was evolved, that the handling of a commission does not consolidate into good qualities.

Yet the signal service, in general, it exists and it strives to be an enormous reservoir of weather data. In accuracy of collection, in speed of detection and distribution to distant points, in exactness and integrity even of its ephemeral publications, the service is not to be excelled, but as it is even approached by any other weather service in the world. In attaining this, the men of a small, remote, peculiar branch of work and a large number of special forces and of various branches of the present day have, and in the course of the past, been at all times and in all places, the backbone of the service as observers as well as the staff that at the greater part of times, it requires its administrative affairs and other assistance in the ideas, suggestions, etc. that it needs. The men, observers in charge of stations throughout the country have not been at a station for a week or a month or a whole of weather prediction and their meteorological observation which is the service. More than one-third of the men have, of large of our own have had the benefit of some college training and the satisfaction of observers with their station is evidenced by the fact that their average length of service has been 14 years, while the entire life of the service has only been 20 years. Many a small percentage of the observers have left the signal service save to benefit themselves by accepting of a more responsible position in a specialized character which offers a large opportunity to those who sought their connection with the signal service.

The military staff of the signal service has in these years worked under the greatest possible disadvantages, receiving no credit nor pay for the great number of weather duty. Their positions are in the army. If a sufferer from that disease from their service, they received small acknowledgment and honor from other sources. If a man while serving on the duty

has also served in the army in a large city as to prevent officers from serving in a small town and rather of observing with their regular military duties. As the time has passed, there have been obtained for special duty, but not more than a dozen have ever been allowed to remain for any length of time and the number of these men subject to a dangerous depletion by promotion, resignation, or the assignment of other and paid duty bringing preference









## *Index collected by the Signal Service*

14. Monthly wind travel at principal and representative stations, 1881-1888.

The following table shows the principal observations and researches of the service, made for each hour of the day at intervals of the year 1900, from 1881 to 1888.

15. Charts with tables of synoptical data from two to eight stations showing for each month, from 1881 to 1888, the Territory Nevada, Oregon, New Mexico, Utah, and Washington state the average precipitation and the greatest and least rainfall for each month of the year.

16. Climate charts are taken at other widely distributed points, the temperature, mean sea level, frost, evaporation, and the direction of the wind, at New York, Texas and Washington.

17. Climate charts, signed and tables from the stations at the principal waterways, from Arizona to California, Colorado, Nevada, New Mexico and Utah.

Many other reports of the service, including all the extended observations, and a table of the reference was made by the service, and chart of the daily temperature for the year, and general climate for New York, both prepared at the office of the Signal Service.

The annual reports of the service, and other reports have been appended to the principal publications, which have been published in the service, and are also from the reports of the service. For several years the annual report of the service, and the principal reports of the service, have been published in the service, and the principal reports of the service, have been published in the service, and the principal reports of the service, have been published in the service.

The annual work of the Signal Service of the army, and the service, and the principal reports of the service, have been published in the service, and the principal reports of the service, have been published in the service, and the principal reports of the service, have been published in the service.

The principal work of the Signal Service of the army, and the service, and the principal reports of the service, have been published in the service, and the principal reports of the service, have been published in the service, and the principal reports of the service, have been published in the service.

for the study of tides and low waters (p. 10), have also accumulated special applications, as a year or so ago we could not tell what impact the cat rest in the weather work had taken from the experience with wave height measurements. The high degree of success in these latter studies was also recognized by those interested in the problem with my own interest. The accuracy of observed and forecast of the tide surface on the off-shore of the coast of the United States, and the value of the tide surface have been found to be a most satisfactory result.

In part the nature of the work is such that it is possible to do a great deal of work in the field, but it is not possible to do a great deal of work in the field, and it is not possible to do a great deal of work in the field.

The spirit of the work is such that it is not possible to do a great deal of work in the field, and it is not possible to do a great deal of work in the field.

The spirit of the work is such that it is not possible to do a great deal of work in the field, and it is not possible to do a great deal of work in the field. The spirit of the work is such that it is not possible to do a great deal of work in the field, and it is not possible to do a great deal of work in the field.

The spirit of the work is such that it is not possible to do a great deal of work in the field, and it is not possible to do a great deal of work in the field. The spirit of the work is such that it is not possible to do a great deal of work in the field, and it is not possible to do a great deal of work in the field.

The spirit of the work is such that it is not possible to do a great deal of work in the field, and it is not possible to do a great deal of work in the field. The spirit of the work is such that it is not possible to do a great deal of work in the field, and it is not possible to do a great deal of work in the field.

The spirit of the work is such that it is not possible to do a great deal of work in the field, and it is not possible to do a great deal of work in the field. The spirit of the work is such that it is not possible to do a great deal of work in the field, and it is not possible to do a great deal of work in the field.

The spirit of the work is such that it is not possible to do a great deal of work in the field, and it is not possible to do a great deal of work in the field. The spirit of the work is such that it is not possible to do a great deal of work in the field, and it is not possible to do a great deal of work in the field.

be mentioned International meteorology, Langley's magnificent and unique work at Mount Whitney, the contributory observations for the Fish commission, demanding special instruments and sometimes extra observers; extensive and, as Professor Hail said, "indispensable aid during this transition period" in climatological and other work throughout the extent of all Alaska; coöperation with the Polaris expedition; the Cumberland sound work; the solar total eclipse of 1878; the investigation of the forest plague; the point Barrow and Lady Franklin bay expeditions, which otherwise could never have started; the Labrador expedition; the Death valley investigations; and the western Africa eclipse expedition.

It should be borne in mind that the civilian organization now in operation is due entirely to the military force. The lately lauded system of local forecast officials at the more important cities is simply a continuation of duties initiated several years since, and which, as to name, compensation and scope of work, were planned and carried into execution by officers of the army.

The estimates and proposals for liberal pay to civilians in the reorganized Weather bureau were also the work of an officer, and the pay obtained was not only considered exceedingly liberal by the legislative branch but also by the civilian organization, as evinced by the omission of two professors of highest pay from the estimates of this year.

In résumé, it has been shown that the Signal corps of the United States army has so conducted the meteorological work entrusted to its charge as to develop and advance meteorological investigation to very near the dignity of a science, partly through the high class of work done by the service and partly by the stimulus it has given to this work through its international system and other liberal methods; that the practical application of weather forecasts has attained a degree of perfection unexcelled, if even equalled, by any other nation; that its system of river observations and flood forecasts, taking into consideration the enormous area of the drainage basins and the unparalleled amount of material interests concerned, has reached a stage comparing most favorably with that of any foreign country; and that the graphic and tabular data representing the climatic elements of precipitation, temperature, wind, sunshine, evaporation, humidity, prevalence of cloudiness and probability of rain, have

covered the entire United States with a fullness and perfection of detail unknown over any other equally extensive area on the face of the globe.

It is believed that no branch of meteorological or climatic investigation has been neglected by the army administration of the Weather bureau, and the character and reliability of the work thus done is submitted with confidence that it will stand the test of investigation and discussion as well as that of any other department of natural science through a period of equal length to its organization, development and transition upwards.

One broad field opens up to the Weather bureau under its happy organization, freed from the heavy burden of conflicting duties foreign to scientific work, and in this field of the relation of weather and climate to agricultural productions the prospects for great usefulness is possible. This field the army administration made unavailing efforts to cover through coöperation with the department of agriculture, but to a bureau of its own this department will no longer maintain an indifferent attitude such as was displayed toward the army.

In its development in this and in all directions, and in the efforts of its professors and advocates to place meteorology among the acknowledged and exact sciences, the United States Weather bureau has no more interested or friendly sympathizers than the officers of the army who have contributed by their labors to the perfection of the splendid, practical system on which this bureau now rests.



